ADVANCED TECHNIQUES IN TECHNICAL DOCUMENTATION

H. LEE SHIMBERG

Introduction

The advertised title of my talk "Advanced Techniques in Technical Documentation" is rather formal and perhaps a bit overblown. In the time allotted, I am going to discuss four techniques broadly, rather than one in depth, in the hope that there will be at least one new idea or application for everybody. The four techniques

A technical instruction book without text

SIMM, a better way of arranging technical information

troubleshooting template, a device that enables the technician to locate a defective part more easily than by using conventional troubleshooting manuals

a computer assisted troubleshooting method

are all really quite simple when you consider the elements of each which we will be doing together today. There is nothing wrong with simplicity, however, and frequently nothing trivial. To make this point quite clear, I recall a conversation I had with one of our very senior technical people about ten years ago, who was describing to me the awesome magnitude of a job to devise a fire control scheme that would allow us to fire a rocket from a submerged submarine against an enemy submarine at a relatively great distance whose location was not precisely known and whose destination was a matter of conjecture. Add to that the requirements that the rocket be fired from any of a number of depths, be programmed upward into the air, fly some distance, then drop its rocket motor at the right point so that the business end could come down at the right place--and add on top of that the fact that you had to do all of this from an unstable platform and you can see why this man sighed as he described the problem.

Well, we solved that problem and in so doing, developed an effective ASW submarine rocket (submarine launched anti-submarine rocket), giving attack

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submarines a vastly greater capability than they would have if they carried only torpedoes. But, at the same time, another Department had a very different problem and one that at first glance seems to be much simpler to solve--that is to develop a weapon for an underwater swimmer that will allow him to kill sharks without getting himself killed. When you consider that one of the constraints put on this weapon was that it could not draw the shark's blood, the size of this "simple" problem becomes crystal clear. The other major constraint of course was to be able to kill the shark before it could attack the swimmer. We solved the fire control problem but we still don't know how to kill a shark with safety to the swimmer. So, solving an apparently simple problem is not always simple at least not until the solution is found. As an aside, glory and perhaps near greatness can be yours if you can solve the shark problem. The point is that just because something is simple does not mean that it isn't or can't be very effective.

But I don't want you sitting there thinking about how to kill sharks. Any ideas, of course, will be gratefully accepted, but for the next hour, let's get back to technical manuals and better ways of doing things.

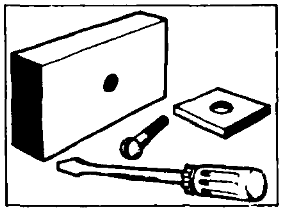
Non Verbal Presentation of Technical Instructions

I use this rather imposing title for this portion of my talk because it is the title used for an article in the 4th quarter 1967 issue of "Technical Communications". Actually, I prefer "Book Without Words" and others have indicated a preference for "Picture Book". Since some of you have already read the aforementioned article--and it is readily accessible to all of you--I am going to describe the task from a viewpoint slightly different from the author's--that of the illustrator assigned to work with him.

To get you oriented, the Naval Ordnance Laboratory was required to design a weapon that would be effective in its intended environment (or tactical situation) yet that would be assembled, transported, and otherwise handled by persons with less than a perfect command of English. A great deal of thought was given to attempting a technical translation but the imponderables and practical difficulties caused us to abandon that course. Accordingly, it was decided to eliminate the use of text in the supporting instructions. This left us with the choice of technical art published either in a manual or presented in some film medium.

Because of assembly options that would be difficult to explain by film, particularly a silent film, and also because of the cost of projection equipments and logistic difficulties they offered, we decided on the book without words.

The first slide--a reproduction of one of the figures of the "Technical Communications" article--shows the general nature of illustrations produced. In order to produce this kind of illustration, the usual close rapport existing in any good writer-illustrator team had to be enhanced because of our total dependence on effective illustrations.

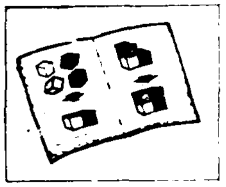


This is how we did it. At the outset we decided to enlarge the team to include the principle engineer and a photographer. This is not to imply that we usually work without these people--we never do. On this project the real difference was to make them "in" rather than outside, infrequent participants.

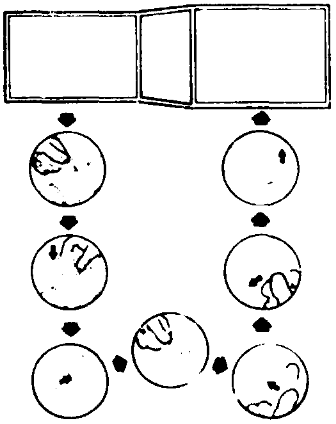
Usually the number of pictures required to illustrate a particular job or procedure was determined by the illustrator who listened to an explanation of the task as taken from the day's shooting script prepared by the writer. In many cases, several views of the object being worked on were made with selection of best saved for later.

As explained in the "Technical Communications" article, each sequence was always started by a no-action shot. Every view thereafter was devoted to a specific action, required of the user to build up his weapon.

The layout chosen--two pictures on each 8 x 10 page, is interesting--at least to me. This particular layout was chosen for two reasons: (1) to assure adequate space to be able to show the action clearly, and (2) to force the viewer to concentrate on one step at a time. The desire here was to lead step by step and not attempt to show the whole job panoramically in the fear that this approach might confuse rather than assist.

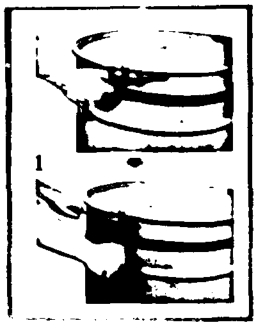


The next slide shows an alternate panoramic layout using a double page spread. The no-action views have a square background--the action views round--the left hand square is the "before" view--the right hand square the "after". Whether this approach would have been more or less effective, I can't say for we didn't try it. If we do another picture book, we will do it both ways and test each.



The procedures selected for illustration were fairly easy to pick; sometimes, however, the planned way to do it was modified because of the way the technician actually did it. That is, we modified preconceived methods when they were in conflict with a natural method. Similarly, we sometimes found it necessary to change the order of the steps. We kept track of the sequence as originally planned by marking each of a series of 2" x 2" squares on a

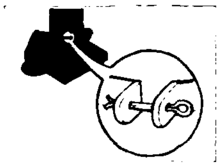
sheet of paper with the filmpack negative letter and number. We also used short titles on each square e.g. "removal of safety pin" to help us keep track of where we were.

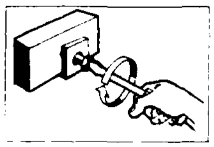


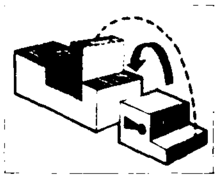
A vital factor to the success of the technique was the decision to break down each job to a reasonable low level so that not too many steps were required to do it. We assigned each whole job a number--for example, uncrating the equipment was a job #1. I'll come back to an added utility of numbering the jobs in a moment.

You might be interested in a few techniques we adopted to solve a few minor problems encountered in the picture taking process. We adopted as standard practice having the illustrator view the shot before it was taken. All hardware needing painting (in the illustrator's view) had been painted. He then used a piece of chalk to pick up a highlight or eliminate a shadow. OKing the shot before taking it reduced the number of takes that otherwise would have been discarded because of poor camera angle or bad focus on the particular item of interest.

Where photography alone could not do the job, the illustrator made a line drawing of the detail and exploded it out of the picture.





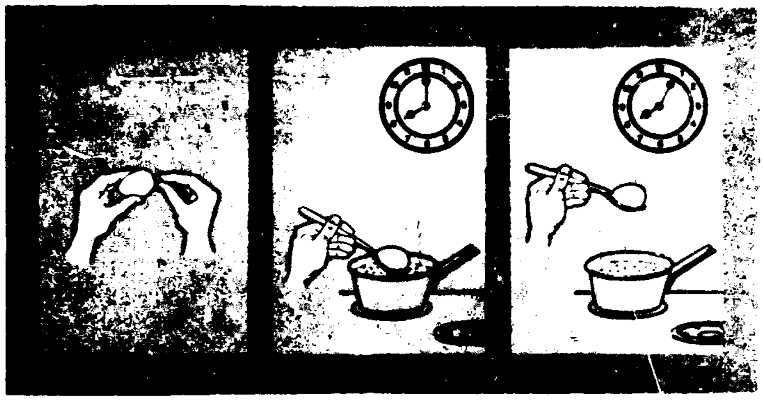


We used ribbon shaped arrows to show direction of rotation and dashed lines behind arrows to show motion. We phantomed a moved part to show where it was before we moved it.

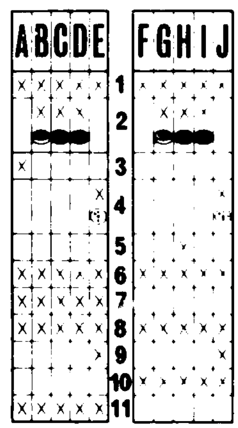
We semimasked areas by cutting out the segment of translucent overlay over the portion of the picture we wanted to pop out.

A few major problems deserve special mention. In some cases you cannot progress from step 1 to step 2 without the passage of time. For example, if you are instructing a new wife on how to boil an egg and doing it by picture book techniques--i.e. no words--and isn't that a refreshing thought--you have to show water being boiled, an egg (properly pierced) being put in the boiling water and then a wait of 3 to 4 minutes, depending on your taste. How to show the time lapse?

We solved that problem by putting a clock on the wall showing the time at 8:00 o'clock when immersing the egg and 8:04 when removing it.



The last remaining problem was the matter of options. As with an automobile the user had a number of options to choose from depending on intended use. There were three different versions of a major element each of which could be used in several kinds of combinations, leading to a total of 10 possible configurations. This problem was neatly solved by painting the three different versions of the major element distinctly different colors and using color printing in the book to show in graphic form how to make up any of the 10 combinations. Remember the job numbering scheme I said we'd come back to? On this slide you see all 10 combinations identified by letters across the top, you see our three psychedelic beauties and you see all the jobs identified by number necessary to perform to get the desired combination.



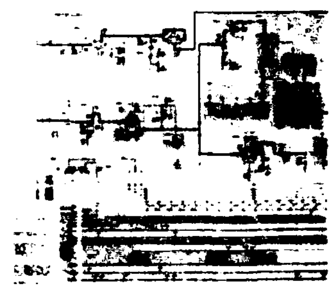
As I said before in connection with layout there may have been other effective ways to do it; so too is the case here. I said we'd try other ways if we ever are lucky enough to get another tough job like this one to do. If any of you do a book without words, we'd like to hear about techniques you use. Whatever of our techniques you change, and you can change almost anything, don't deviate from the concept of the team. Without our team of writer-illustrator-engineer-photographer working as a single unit, I wouldn't be telling you about our picture book today.

SIMM

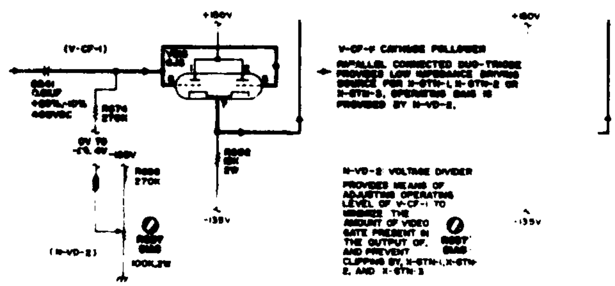
SIMM means "Symbolic Integrated Maintenance Manual", which is quite a mouthful, but really what we are talking about is rearranging all the information normally found in a standard technical manual in such ways that the

user, generally an enlisted technician, can get the information he needs several times faster than he could with a standard manual. This is done in several ways which I will describe to you briefly.

The SIMM manual includes three or four major innovations and a few minor ones. We will consider only the major innovations, and then only broadly. For those of you who are interested in more detailed information, I have a specification which can be consulted later.



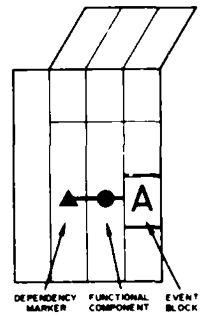
The first of the major features is the precise access functional block diagram and precise access blocked schematic each with an accompanying text. Let's look at a portion of a blocked schematic; the functional block diagram (not shown) is laid out in exactly the same manner. Your attention is called to the use of grey and blue shades. The purpose of the grey shades is to outline the physical location of the circuit or circuits shown in either block or schematic form. The purpose of the blue shades is to identify a function. Therefore, if a single printed circuit (PC) card physically contains an oscillator and amplifier, you would see one grey block in the approximate shape of the card and two blue areas, one for the oscillator and the other for the amplifier. Each functional circuit is identified with codes such as OSC for oscillator and AMP for amplifier rather than with meaningless designators such as V1 and V2. Signal paths are shown by use of heavy black lines with arrowheads. Operating controls and test points are identified by white areas. The identical layout used to show the diagram is then used to house the explanatory text which is published on a facing page. To make this clear, we will examine one block of the schematic. This means that the manual writer must pack all the information about the oscillator into a box the same size as used to show the circuit in block or schematic form. This arrangement has proved to be extremely successful in that the user can immediately identify the location of a circuit, understand its function and its relation to the elements of the equipment very readily.

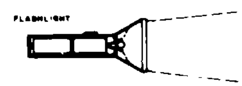


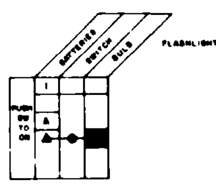
As powerful a device as the blocked functional and schematic diagrams and the accompanying text have proved to be, the operating and maintenance tools have been even more effective. Turn-on and checkout instructions are put in chart form with a left-hand vertical column listing the steps to be performed in sequence and a top strip listing the visual and other indicators an operator checks. The same format is used in the development of a troubleshooting chart which is called a maintenance dependency chart. We will

spend the rest of our SIMM time on this one aspect of the manual because of its importance.

The maintenance dependency chart consists of a left-hand column containing the turn-on or checking steps to be performed and the top strip identifies circuit components. This horizontal strip is nothing more nor less than a tabular representation of a schematic diagram. You could prove this to your own satisfaction by taking such a strip, drawing the conventional schematic symbol for each item, and connecting them with lines representing wires. Why do we go to this tabular format? The answer is so that the interdependency of each circuit component can be shown graphically by use of three basic symbols: a circle or dot, a triangle, and a box. The dot represents a functional component; that is placing a dot under a relay indicates that the relay is functionally involved in the dependency string shown. The triangle, called a dependency marker, is used to indicate the dependency of one event (such as availability of a voltage) upon another event. The box represents an action or indication discernible to an operator or troubleshooter. To illustrate, the simple operation of a flashlight can be represented by the most basic dependency structure we have--a triangle, a dot, and a box. The items identified along the top strip could be a switch and a bulb. Under the batteries we place the triangle and by footnote indicate that three volts must be available, under the switch we place the dot and under the bulb we place the event box. In the left-hand procedures column, we would simply push the switch to on. The event box shows (by the word "LIT") that the desired event must occur if the preceding conditions are satisfied and the event indicator itself (in this case the flashlit bulb) is good. In summary then, if the event indicator is satisfied--that is the flashlight lights--it means the bulb is good, the switch is good and the necessary voltage is available from the batteries. If it does not light, the troubleshooter must check each item involved usually in the most logical order. Actually for situations as trivial as this, a maintenance dependency chart is not needed; indeed a maintenance dependency chart is not effective unless more than one functional relationship exists. Moving to a slightly more complex situation than the flashlight, say to one where the power supply is used to do more than one thing for example light a lamp and run a fan, we know the power supply is good if the fan runs but the lamp doesn't light. We intuitively know to replace the lamp bulb because it is the logical thing to do. This is precisely how the maintenance dependency chart works which will become clearer by now considering a significant example.

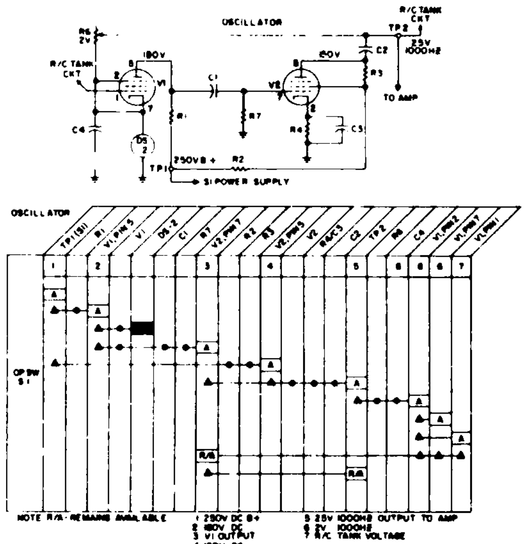






The top half of this diagram is the schematic of a very simple oscillator in its conventional form. (In a SIMM manual it would of course have been shown both in block diagram and blocked schematic formats.) The lower half is the tabular version of the schematic. Note that every

circuit component and test point shown in the conventional schematic is also shown in the chart. Referring to the chart you will note that the only procedure in the left-hand column is to operate switch 1. This causes all of the events and availabilities indicated by the basic symbols to occur. Let's look at a few of them just to clarify the use of the chart. The A under TP1 means that something is available. The footnote keyed to number 1 shows that this is 250 DC B+. The dot under R1 means that if R1 is good, another voltage, in this case 180 VDC, will be available at pin 5 of V1. Referring to the next sequence of events, we can see by the next dependency marker (triangle) that if the 180 VDC is available at pin 5 of V1, and that if V1 is good (this requirement noted by the dot under V1) that the next event is that the lamp DS-2 will be LIT. The reason the word "LIT" is shown white on black is because this event is a visual indication.



The great utility of this type of troubleshooting device is that it allows the troubleshooting technician to start looking for a suspected trouble at a logical point rather than starting from the top as is usually done with standard troubleshooting tables or even with troubleshooting logic trees.

Suppose for example that the 1,000 cycle voltage being fed to an amplifier is not available at test point 2. The technician need be concerned only with the dependency structure leading to the availability of this voltage. The first two triangles say that the indicated voltages must be available and the next three dots say that V2 and R4/C3 and C2 respectively all must be good for the 1,000 cycle output to be available. To troubleshoot this problem, the technician would proceed by pulling V2 and probably check that first on a tube tester. He would then check for voltages 3 and 4 on the appropriate pins and either find them present or not find them present.

If the #3 voltage (pin 7) was available but--after operating switch S1--the #4 voltage was not, he would follow back along the dependency structure associated with the #4 voltage.

Then, since TP1 has already been proved good, he will find his trouble either in R2 or R3.

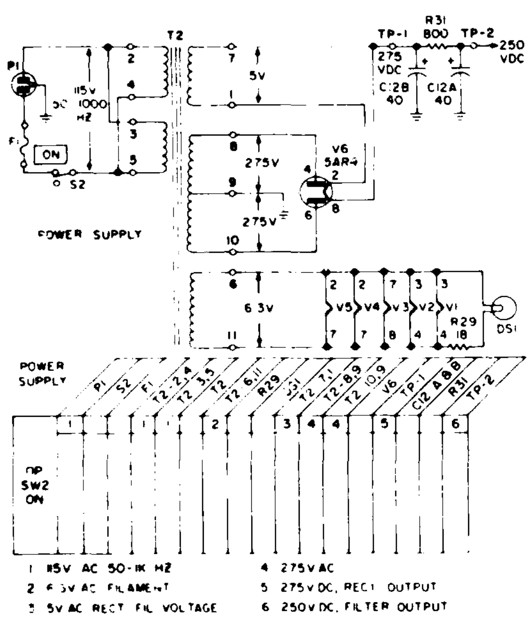
If the #4 voltage was available but #3 was not, then he knows his trouble will be found in either C1 or R7--because the lighting of DS2 has shown the other dependencies along this line to be good.

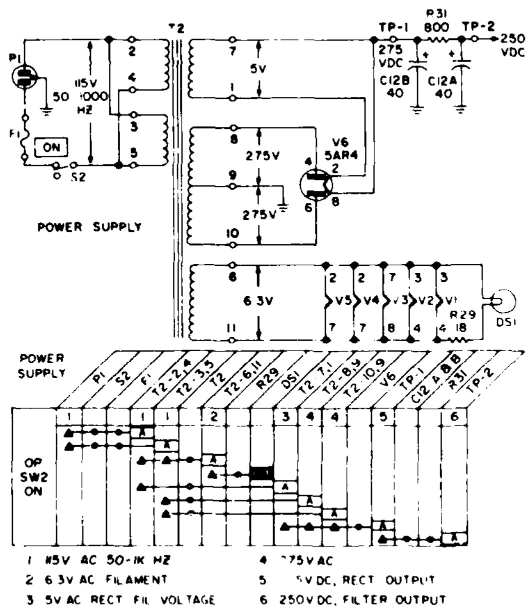
If both voltages are available and V2 has checked out okay on the tube tester, he has only three components--R4, C3 and C2--left to check and that is all there is to it.

He has narrowed the problem down in a matter of minutes to these components, clearly identified for him in the dependency string.

This kind of troubleshooting really works. It has been tested using people with imperfect to zero knowledge of electronics and they were successful in troubleshooting equipments whose operation they did not understand. It was of course necessary to thoroughly explain the use of the maintenance dependency chart. Once that was well understood, however, actual trials showed that an unskilled person could locate a trouble more quickly using the maintenance dependency chart than an electronics technician could locate the same trouble using a standard manual.

This slide as you can see, shows a very simple power supply drawn both in conventional schematic and maintenance dependency chart format. Missing from the maintenance dependency chart you will be quick to note are the basic symbols. I have left them out for those who are interested in trying to place the proper symbols under each component. The last illustration shows proper symbols in place.





Troubleshootihg Template

Any well-organized maintenance manual on complex systems, particularly electronics, provides troubleshooting information in accordance with level of maintenance and capability at each level. Troubleshooting is also packaged by overall equipment configuration, more specifically, system, equipment, and modules. For example, a systems volume will provide information to isolate trouble to a single major equipment, such as a transmitter distinguished from a receiver. The equipment manual will provide diagnostic information down to the lowest removable and replaceable component. In many situations, this is as far down as maintenance goes in the U.S. Navy. That is, there is no requirement for the user level to repair defective modules. This philosophy has obvious shortcomings when applied to modern submarines. Some of these are as follows:

1. Depletion of operational spares while Naval ships are on extended cruises.

2. Excessive time required for repair of defective modules by depot or manufacturer.

3. Possible down time of major equipment due to exhaustion of operable spares.

4. Difficulty in determining the quantity of a single spared component which should be provided on the ship's allowance list.

Information to repair such components has usually been presented in a component repair manual. Unfortunately, such manuals tend to get as lengthy and as complex as the basic manual on the overall system. A part of the reason for this is that such manuals tend to duplicate much material presented elsewhere.

In order to eliminate this problem, it was decided to search for a better technique for the end user, in this case a rated technician aboard a submarine, that would have at least the following characteristics:

1. It should present a maximum of information in minimum space.

2. Should be less bulky than a comparable conventional manual.

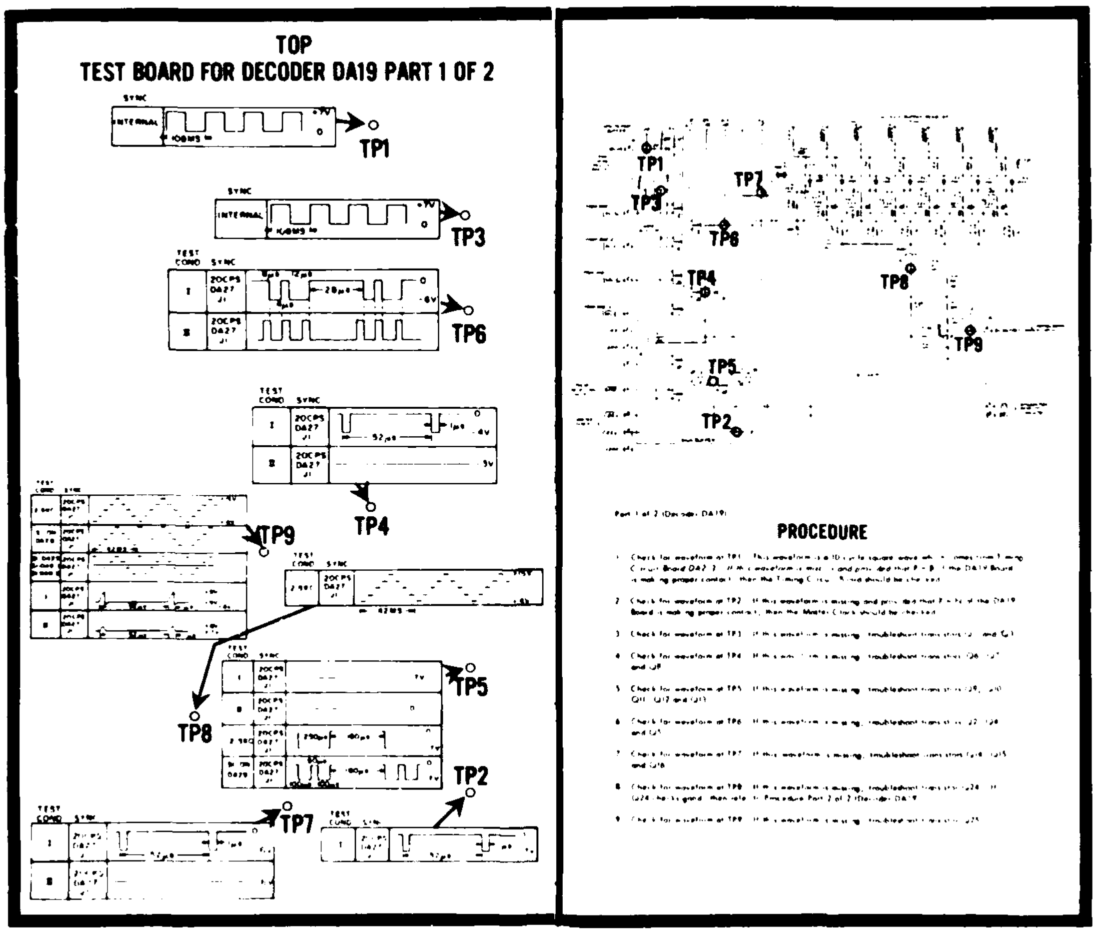
3. Should be easy to use and not require specialized training on the part of the user.

4. Should take over where existing manuals leave off and provide complete information for repairing a defective module.

To proceed from the theoretical to the concrete, consider any electrical system with many parallel identical circuits as commonly occurs in sonar, fire control and computer systems. We have long felt that such systems having many identical removal modules could be repaired with a mechanical device rather than with a component repair manual. We therefore designed

the troubleshooting template which fits over a printed circuit board and incorporates all the diagnostic information normally found in the repair manual. This information, which consists of waveforms and voltage and resistance values, is placed adjacent to associated test points. The technician's first task is to locate the bad printed circuit (PC) board using information in the equipment manual. This procedure so far does not differ from the conventional. Once a bad PC board is located, one can opt to replace it with a good one or proceed to troubleshooting on the spot. He does this by pulling the PC board out and reconnecting into the circuit by means of a board extender. He then clamps our troubleshooting template over the board and, using the designated troubleshooting equipment, follows the procedures starting with TP1.

I would like to call your attention to some of the features of our template. You will note that the schematic diagram locates each test point, making physical identification of probable defective piece parts simple. Also, the TP holes are drilled so that a meter or oscilloscope probe will be positioned directly on the point to be checked. This eliminates such unhappy practices



as putting a probe of a meter set to read 3 volts on a point which has 300 volts on it.

We have tried this device out in an experimental way only, putting it aboard several submarines and trying it out in Sonar schools.

Reaction has been enthusiastic in all cases. Users have found the template easy to use. We supplied the users with a known defective card--and the users were able to localize the defect, a bad transistor, within 15 minutes.

System Testing and Troubleshooting by Own Computer

The motivating force behind the never-ending search for better ways to present technical information is to make the user more effective.

In the case of operating instructions, we strive for a good technical manual produced in the hope that the operator will use the expensive and usually complex equipment entrusted to his care intelligently. We want both sonarmen and fire control technicians, for example, to be able to distinguish instantly between a submarine and a whale. Equipments are designed to do this with the support of training and a good technical manual.

When we consider corrective maintenance, i.e. troubleshooting and repair, we are even more concerned with effective technician performance because we want to "stay on the air". That is why the SIMM technique was invented; that is why we try techniques such as troubleshooting templates and that is why we are now trying computer assisted troubleshooting--again to simplify the technician's task and minimize "down time".

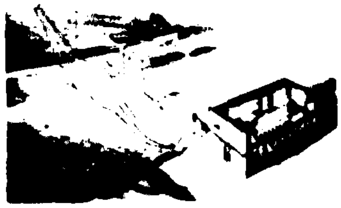
Several computer assisted troubleshooting systems have been devised in recent years.

One type utilizes a central storage bank which is queried by remote users.

Another incorporates a computer in a special purpose complex of test equipment which is connected to all operating systems. In this case, the computer matches system outputs against expected outputs and provides readouts when something is wrong. This is how all the systems aboard the world's largest aircraft, the USAF's C5A GALAXY, is checked.

Last May at the 15th ITCC, Mr. Joseph Glogan described a unique troubleshooting system in which test tapes produced by an IBM 360/50 computer are run on a special purpose computer to check operating systems. The tapes are also used to produce printed technical manuals.

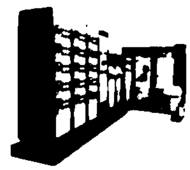
The system I am going to describe now is a little different from any of the other known computer assisted troubleshooting systems in that a computer that is an integral part of the system is used to troubleshoot the rest of the system. Here is how it is done.



The first slide is to get you oriented; this is a view of a degaussing range.

The purpose of the degaussing range is to measure the magnetic fields of ships so that these fields can be minimized by adjustment of coils installed

in the ship for that purpose. The purpose in minimizing the field, of course, is to make the ships less vulnerable to attack from magnetically actuated weapons such as mines and torpedoes.



Up to the present time, the procedure was for a ship to traverse a range of underwater magnetometers connected to recorders in the range station. An engineer or other highly trained (and therefore expensive) person, e.g. physicist, would read the tapes and make calculations enabling him to instruct the ship's Captain on adjustment of the ship's degaussing system so that the ship's field could be minimized. The purpose of the computer in the new system is to read the signals, make the necessary calculations, and type out the answers on the computer's associated typewriter. This eliminates the need for the engineer--now only a sailor is necessary to relay the computer's calculated instructions to the ship.

A technical manual is necessary for description and operation of the system, but how about maintenance? We believed that most of the trouble-shooting and periodic routine checks could be largely performed by the computer, utilizing spare memory storage.

Accordingly, a diagnostic tape was programmed which instructs the sailor via a typewriter printout what to do. After the sailor follows the computer's instruction, the computer learns whether that particular segment of the system is operating properly or not--if it is, it tells the sailor to go on with the next act--if it is not, it tells the sailor what is most likely wrong so that he can go right to the systems component and check it or repair it. To make this computer-man team operation clearer, I will oversimplify by selecting an almost trivial problem. Let us suppose that the diagnostic routine begins by telling the sailor to turn the on-off switch to on. If the system is energized the computer knows it, because the power supply of the system sends a little signal to the computer just as it does to the pilot lamp on the control panel.

When/if the computer gets the correct signal, it knows that the sailor may proceed and types out "turn switch to 750". To keep to our almost trivial example we won't consider what happens next but instead go back to the first instruction and see what the computer tells the sailor if it does <u>not</u> get a signal from the power supply. This tells the computer that either there is something wrong or that as an alternate possibility, the sailor has goofed. In this case, for him to goof he would have had to fail to throw a toggle switch from one position to another. Depending on the complexity of the operation involved, the computer either tells the sailor to check what he has done or else tells him what to check in the system. In this very simple case of power, let us assume that it tells him first to recheck position of power on-off switch and come back and report. The sailor comes back and merely hits the space bar indicating that he has followed instructions and is ready for the next instruction. The computer types back "check fuse"--the sailor goes to the panel, looks at the fuse, verifying that it is, or is not, blown. If it is blown, he replaces it and starts the routine from beginning. If it is good, he comes back and tells the computer by hitting the space bar again. Now the computer knows that it will have to go to work. It then tells the sailor to press the "Calibrate" button (which would put out a 28 volt standard signal if the power supply is working). The sailor pushes the button and comes back and reports.

And so it goes, with the computer telling the sailor what to do and the sailor always coming back and reporting results. This procedure continues until an offending part is located and repaired or replaced. This routine replaces all of the standard troubleshooting and repair information normally found in a manual with the exception of some reference data such as wiring diagrams.

The next slide is a reproduction of actual instructions included in the diagnostic routine. As a not inconsiderable by-product, the computer drastically reduces the time required to put the system in operating condition for the day's work. One can appreciate the computer's potential when you realize that the station has 15 magnetometers at each of 6 arrays (depths) and that each magnetometer can be set to as many as 12 sensitivity settings. In order for the operator to assure himself that the range can measure the type of ship programmed for the day, say mine sweepers, he must calibrate the array at the depth selected for at least several sensitivity settings. For any particular array (depth) this could require up to 180 manipulations of switches and readings of a null meter.

This is very time consuming and therefore in actual practice, a clever operator reduces time by skipping some of the calibrations, for example, by nulling least sensitive, skipping the next sensitivity setting and going to the third setting. By a pre-diagnostic routine which we will call calibrating the arrays, the computer builds in these short cuts but does it in such a way that all magnetometers and all sensitivity settings get checked. Successful completion of this routine tells the operator that all magnetometers and all associated electronic circuitry (power supply, oscillators, amplifiers) are okay. When he can't get a null for any one of the programmed checks, he goes to the diagnostic routine just described. However, by using the pre-diagnostic routine, he drastically cuts the time it would normally take to find out that something is wrong.